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ATTORNEY CONFIDENTIAL

GROUNDWATER AND SURFACE WATER ASSESSMENT

CARTERET IMPOUNDS
AMERICAN CYANAMID COMPANY
LINDEN, NEW JERSEY

DATE OF REPORT - February 9, 1987

DATE OF PLANT VISIT - May 15-16 and October 9, 1986

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T A B L E   O F   C O N T E N T S

LIST OF FIGURES

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the investigations reported here was to follow up on the Phase 1 investigation completed in 1985 of the potential risk of accidental releases from the Carteret Impounds. Specific objectives of the Phase 2 investigation were:

1. Obtain preliminary field data on the groundwater flow system,
2. Determine whether the sludge contained in the impounds is a hazardous waste based on the EP Toxicity criteria for metals,
3. Determine the total and free cyanide concentration in the solid phase of the sludge and the leachate, and
4. Determine the potential impact of cyanide releases from the impounds on the Rahway River.

An updated version of the Phase 1 evaluation is presented in Appendix 1.

1.2 HISTORY AND CURRENT STATUS

Figure 1 shows the location of the impounds on a portion of the Arthur Kill, New York-New Jersey topographic map. The Carteret Impounds were utilized from 1908 to 1973 for the disposal of process sludges containing alum and yellow prussiate of soda (YPS). The operation of the landfill consisted of combining the alum and YPS sludges to form a neutralized mixture. A series of six impounds were constructed above ground with wooden dikes, and the sludge was pumped from the plant on the north side of the Rahway River to the impounds. Currently, the Carteret Impounds cover about 120

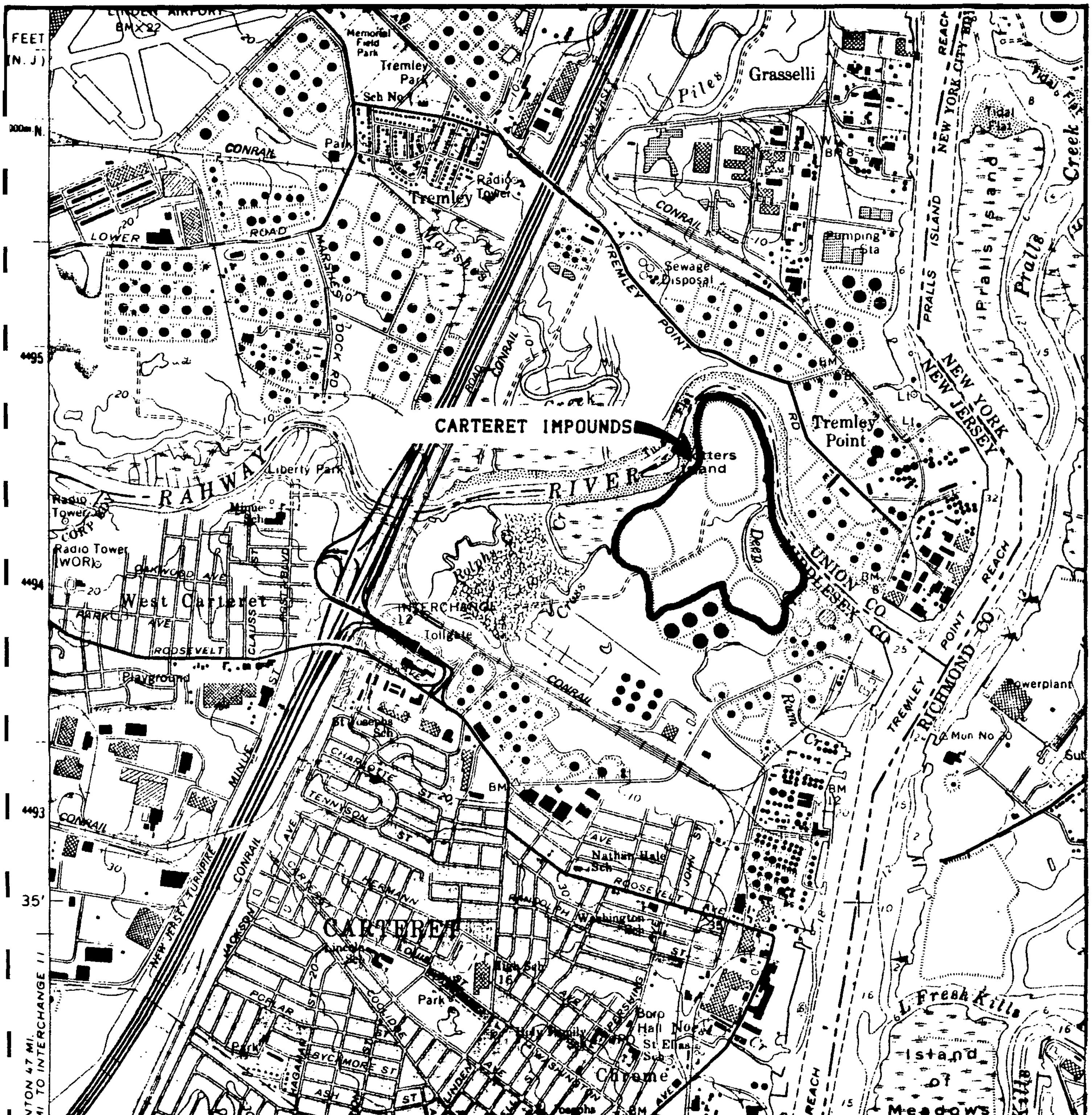

Figure 1. Location map for the Carteret Impounds, Carteret, New Jersey.

acres and contain an estimated 1.94 million tons of sludge (as estimated in the Eckhardt Study form submitted by Cyanamid).

1.2 SITE HYDROGEOLOGY

The inactive alum impounds at Carteret are located on the boundary between the Piedmont and Coastal Plain physiographic provinces. Surficial deposits consist of about 20 to 40 feet of Quaternary alluvium composed of interbedded silt, sand, gravel, and clay with buried peat and organic rich horizons. The alluvium was deposited in a salt-marsh environment. (1, 2)

Bedrock underlying the alluvium is the Triassic-age Brunswick Formation consisting of bedded shales, mudstones and sandstones which attain a maximum thickness of 6,000 to 8,000 feet in New Jersey. (1)

The approximate locations of on-site test borings completed by M. Disko Associates in 1981 (2) are shown in Figure 2. The geologic logs for borings reported by Disko (2) and shown along the lines labeled A-B and B-C in Figure 2 were used to construct the geologic cross-sections shown in Figures 3 and 4. Although not all the borings were completed to bedrock, their interpretation indicates that the top of bedrock is 20 to 30 feet below land surface and 15 to 20 feet below the base of the impoundments. The bedrock unit is the Triassic-age Brunswick Formation (also referred to as the Brunswick Shale and the Triassic Shale). The alluvial sediment overlying the Brunswick Formation generally consists of 4 to 6 feet of meadow mat and 7 to 9 feet of silt with minor amounts of sand, gravel, and clay (2). Based on the interpretation of Disko's boring logs and the manner of impound construction, the meadow mat appears to underlie the entire impounds.

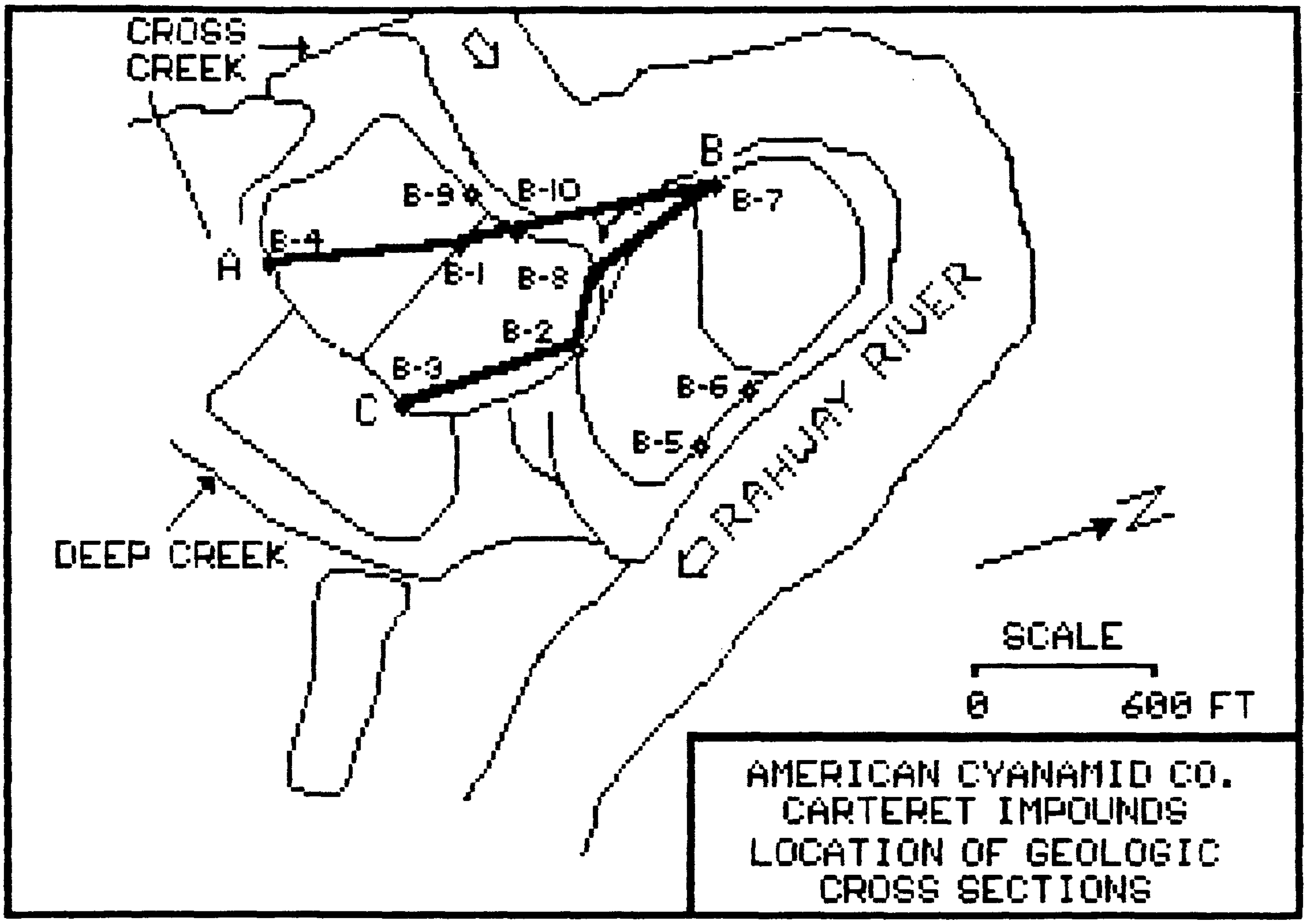

Figure 2. Site map showing the general outline of the five impounds and locations of test borings completed by M. Disko Associates (2).

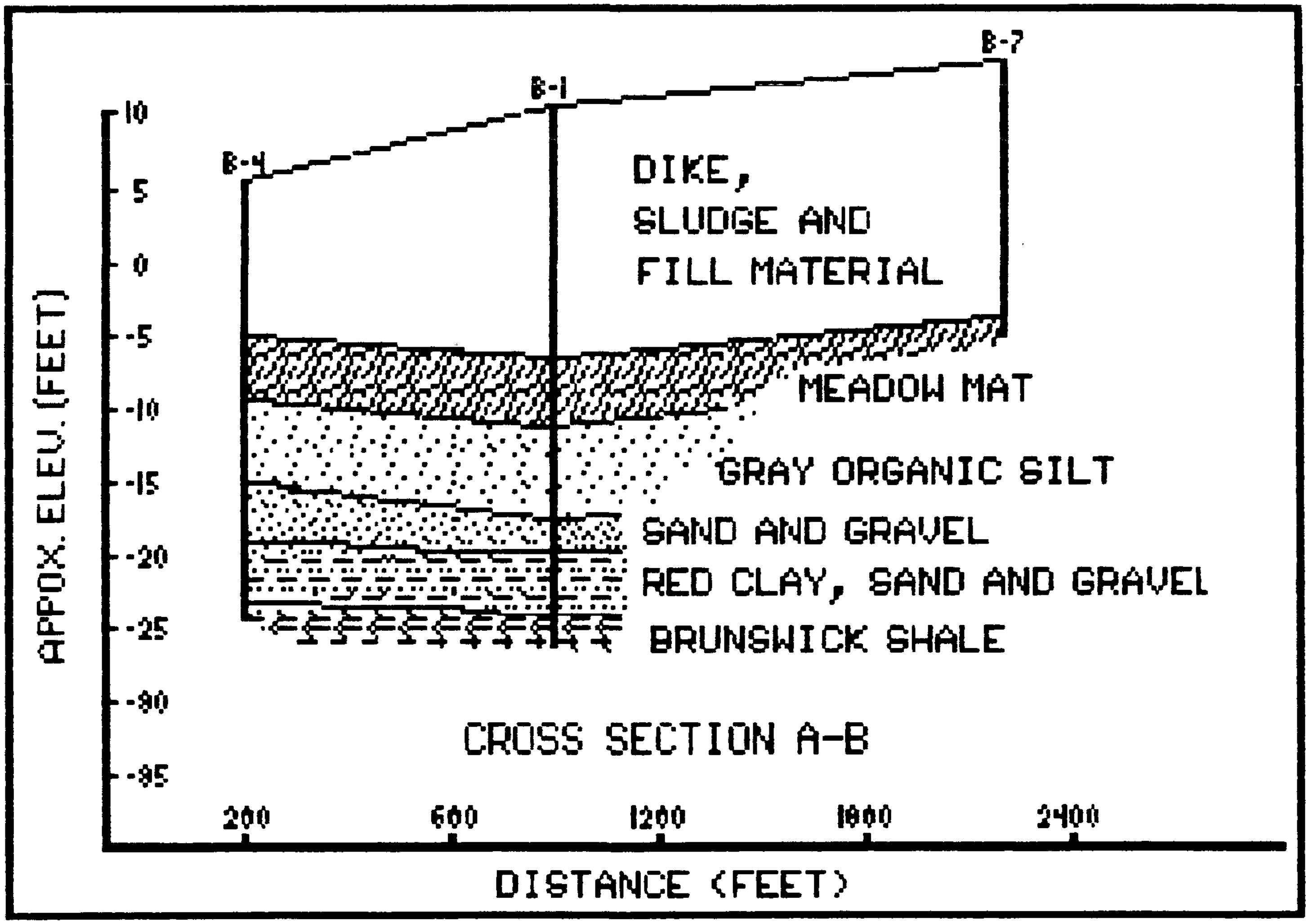

Figure 3. Geologic cross-section along line A-B shown in Figure 2 for the Carteret Impounds.

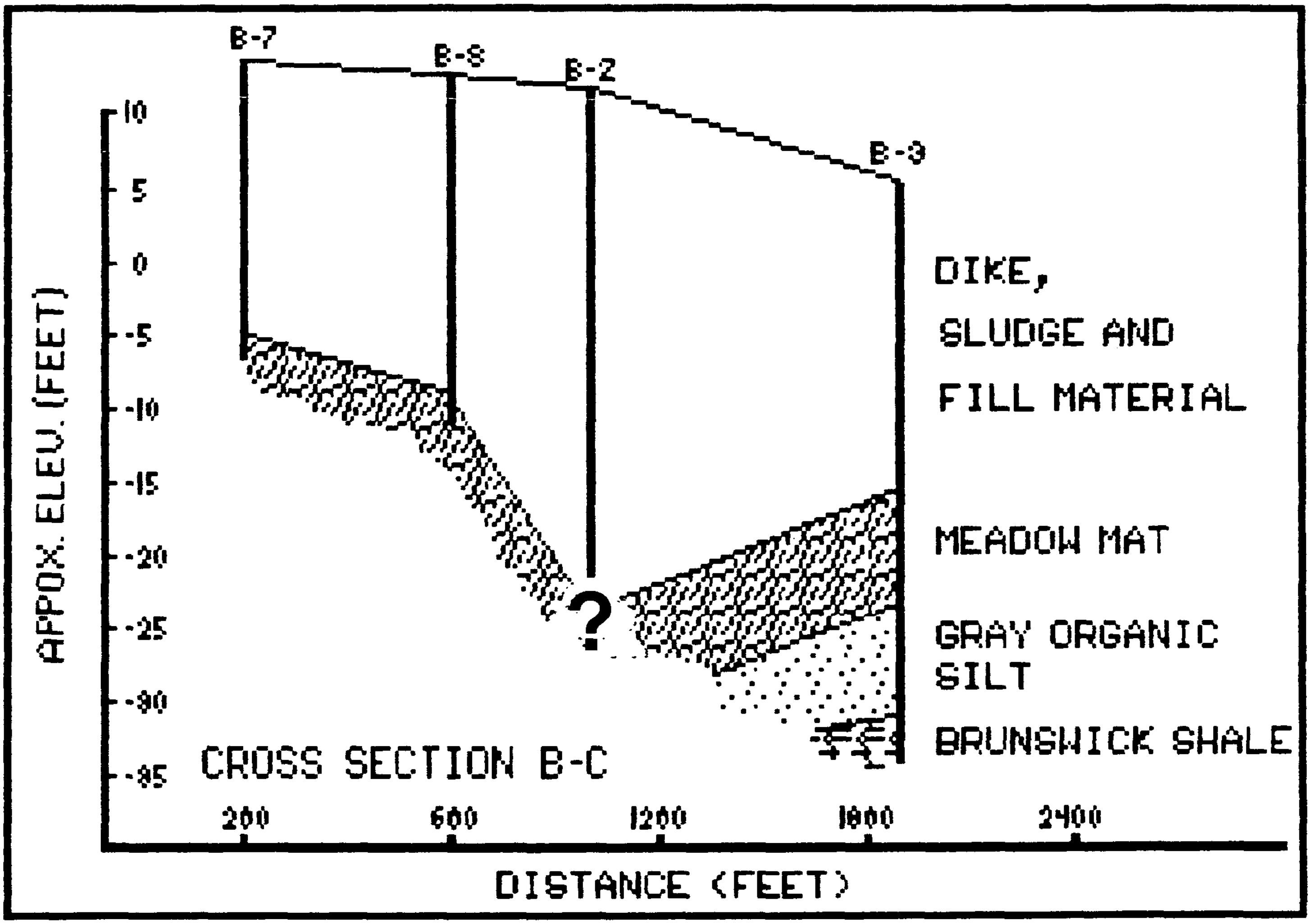

Figure 4. Geologic cross-section along line B-C shown in Figure 2 for the Carteret Impounds.

The Brunswick Formation is a major source of groundwater to the west of the impounds with wells producing from depths of about 150 feet. The groundwater in the Brunswick Formation occurs in fractured shale and may be locally high in sulfate and hardness due to the presence of evaporite deposits, i.e., gypsum and salt (2).

However, it is our conclusion that no water supply wells that produce from the Brunswick Formation will draw groundwater that originates in the impounds. This conclusion is based, in part, on the survey of groundwater usage completed by M. Disko Associates in 1982 (2) that indicates no water supply well is downgradient of the impounds. The closest well is 4,000 feet southwest and upgradient of the impounds near the intersection of Roosevelt Avenue and the New Jersey Turnpike. This well is listed as being owned by Gulf Stream Dev. and has a reported yield of 100 gpm which is too low to cause a reversal in groundwater flow at the distance of the impounds.

The conclusions on the direction of upgradient and downgradient groundwater flow are based on our conceptual model of the groundwater flow system. This model was developed on general principles as described in the paragraphs below.

As illustrated in the generalized cross-section of Figure 5 and the areal map of Figure 6, the groundwater in the Brunswick Formation flows seaward and discharges to surface water, while the groundwater originating within the impounds moves radially outward to discharge into the surface water. This groundwater flow model results in the hydraulic isolation of the impounds.

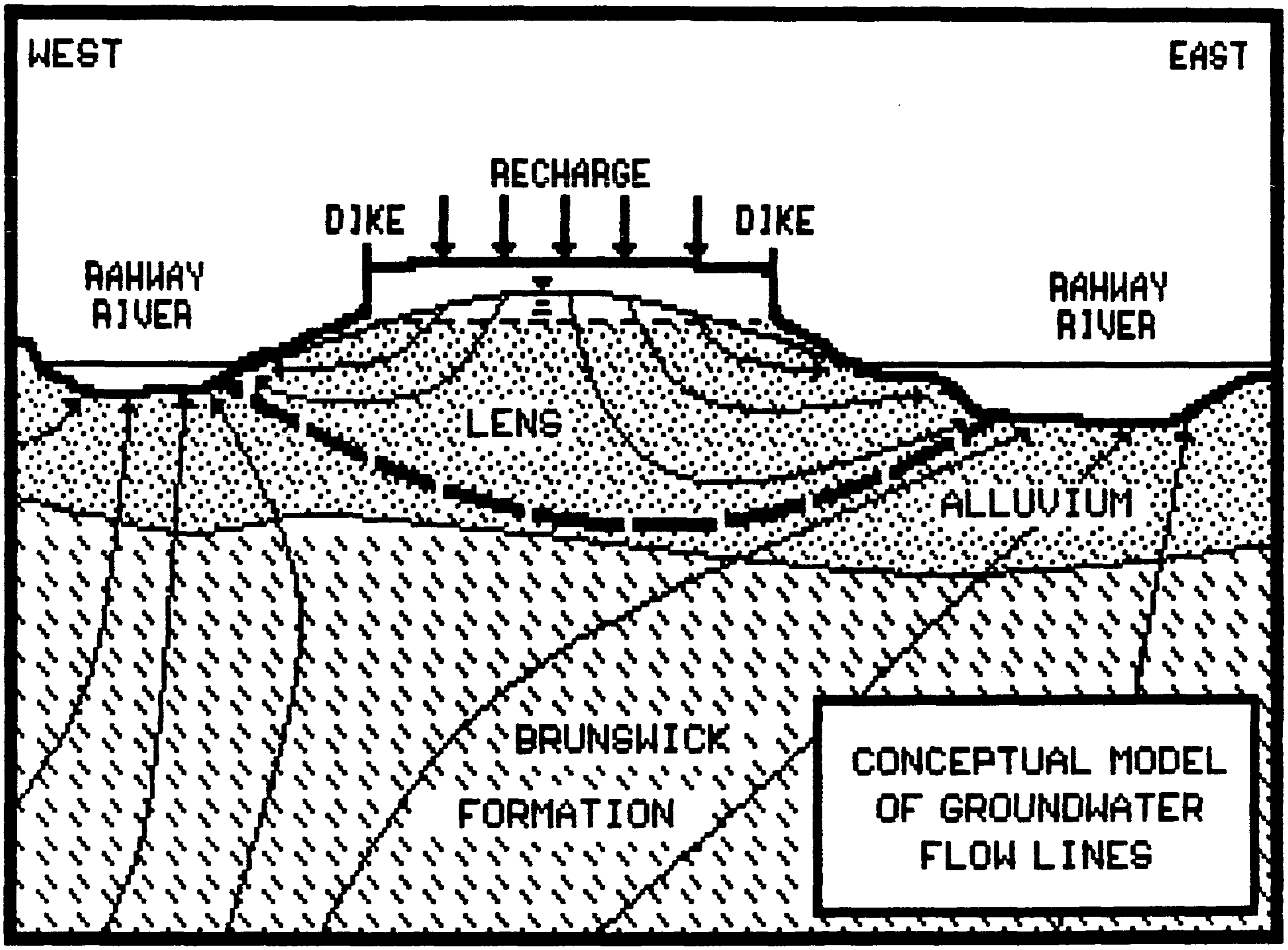

Figure 5. Generalized West-to-East cross-section through the Carteret Impounds showing the conceptual model of the groundwater flow system. Groundwater moves upward out of the Brunswick Formation to discharge into the surface water. Groundwater mounded within the impounds moves radially outward to discharge into the surrounding surface water. The density contrast between the impound leachate and native groundwater and the upward gradient in the Brunswick Formation should limit the extent of groundwater movement out of the impounds to a lens-shaped zone defined by the area above the thick dashed line.

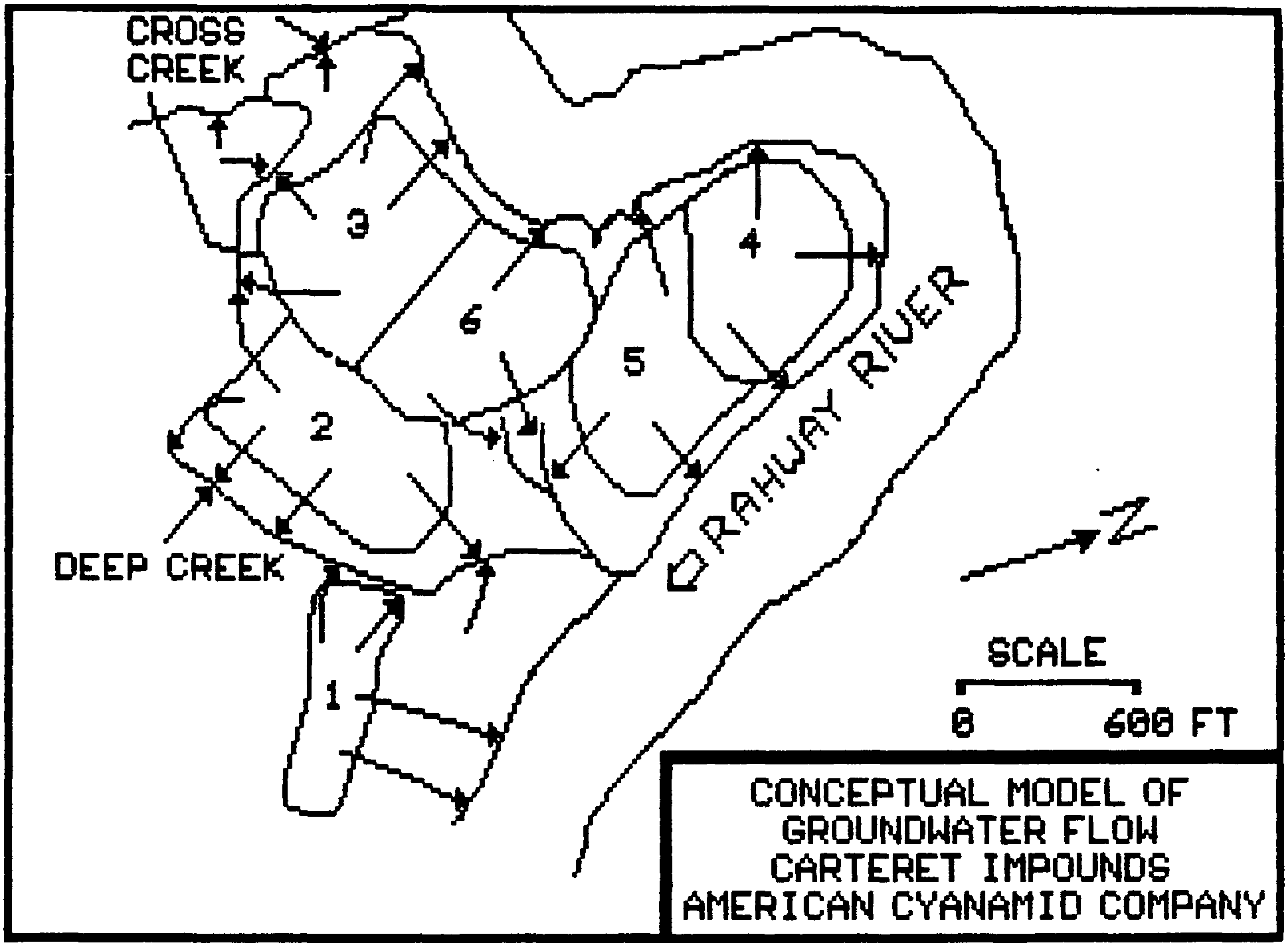

Figure 6. Areal map of the Carteret Impounds showing the conceptual model of groundwater flow radially outward from the water-table mound within the impounds. Groundwater originating within the impounds discharges into the surrounding surface water.

Within the impounds a groundwater mound has developed that raises the water table approximately five to ten feet. The mound generally underlies impounds 4, 5, and 6 shown on Figure 6. The higher hydraulic head within the groundwater mound causes a downward flow component through the bottom of the impounds. However, the upward gradient of groundwater in the Brunswick Formation should prevent significant downward movement of groundwater out of the impounds. To further lessen the downward migration of groundwater out of the impounds, the mounded groundwater within the impounds appears to be less dense than the underlying groundwater as discussed below. The less dense groundwater within the impounds "floats" on top of the underlying brackish groundwater. Thus, the extent of potentially contaminated groundwater is limited to the lens-shaped zone shown in Figure 5.

The density of the groundwater can be inferred from the specific conductivity which is directly related to the concentration of total dissolved solids. The specific conductivities of mounded groundwater in three hand-augered borings completed for this investigation (B1a, B1b, and B2 in Figure 7) were 750, 1,100, and 2,120 micromhos/cm, respectively. Outside the mounded area (in boring B4 and B5), the specific conductivity ranged from 18,500 to 32,000 micromhos/cm. Appendix 2 presents the field data for the hand-augered borings.

2.0 EVALUATION OF WASTE CHARACTERISTICS

2.1 EP-TOXICITY CHARACTERISTIC

Samples of sludge collected from borings B1a, B2, B3, B4, and B5 shown on Figure 7 were analyzed for EP Toxicity by Martin-Marietta Environmental Systems of Columbia, MD. The results of the EP Toxicity analyses indicate that the sludge is nonhazardous with respect to the following constituents:

Arsenic

Barium

Cadmium

Chromium

Lead

Mercury

Selenium

Silver

The results of the EP Toxicity analyses are presented in Appendix 3.

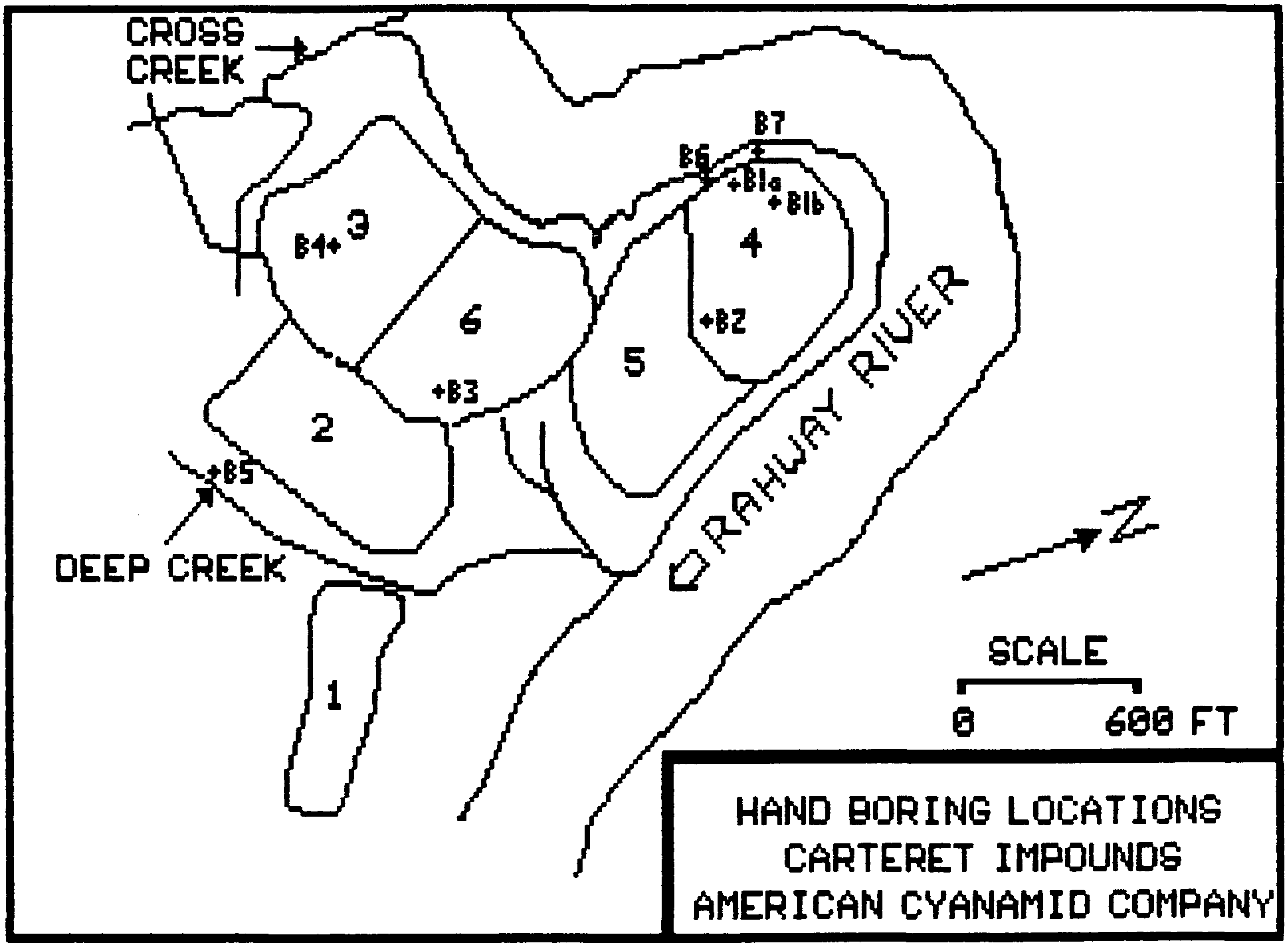

Figure 7. Map of the Carteret Impounds showing approximate locations of shallow hand-augered borings completed for this Phase 2 investigation.

2.2 CYANIDE IN SLUDGE

The five sludge samples for which EP-Toxicity analyses were completed, also were analyzed for total and free cyanide content by Martin-Marietta Environmental Systems. The results of the cyanide analyses for the five sludge samples are presented in Appendix 3. Total cyanide content in the sludge ranged from 433 to 3660 mg/kg, averaging 1130 mg/kg, while free cyanide ranged from 9 to 103 mg/kg, averaging 36 mg/kg.

3.0 LEACHATE AND SHALLOW GROUNDWATER QUALITY

Samples of shallow groundwater inside and just outside the impounds were collected with a Teflon bailer. Access to the groundwater was via the hand-augered borings which limited the sample collection depth to the upper 6 to 12 inches of groundwater. Since the boreholes tended to collapse below the water table, the samples represent grab samples of groundwater at the water table. The groundwater was analyzed in the field for pH and specific conductivity and taken to a laboratory for total and free cyanide analysis.

(Note: In the following discussions, groundwater in contact with sludge is referred to as leachate.)

3.1 pH

The pH of the leachate within the impounds and shallow groundwater is presented in Appendix 2. The pH of leachate was estimated in the field using EM Science "colorpHast" brand pH indicator strips (pH range 0-14, catalog no. 9590). The pH of the leachate inside the impounds was close to neutral (and is reported as pH 7 in Appendix 2), indicating the alkaline YPS and acidic alum were effectively neutralized. The pH increased slightly to pH of 8 in the shallow groundwater in borings B6 and B7, located about 20 feet outside the dike. The higher pH observed outside the dike may reflect intrusion of brackish surface water or mixing with higher pH groundwater. A pH of 8 was measured for the Rahway River along the bank near Borings B6 and B7, which is in the 7.8 to 8.2 range reported for sea water in the open ocean (6).

3.2 SPECIFIC CONDUCTIVITY

Specific conductivity was measured in the field using a YSI Model 33 conductivity meter. The measurement was obtained by lowering the conductivity probe, which is attached to a length of cable, down the borehole until the probe was submerged. The measurement was taken after the meter ceased to fluctuate. Samples of groundwater that are clearly inside the impounds and are interpreted to represent leachate, i.e., B1a, B1b, and B2 (in Figure 7) had specific conductivities of 750, 1,100, and 2,120 micromhos/cm, respectively. For borings either outside the impound or interpreted to represent mixing with the more saline groundwater, the specific conductivity ranged from 18,500 to 32,000 micromhos/cm. Appendix 2 presents the specific conductivity data.

The analyses of cyanide in ground-water from borings B4 and B5 indicate the water is contaminated leachate, although the specific conductivity data indicates the water is part of the underlying brackish groundwater. The likely explanation for this is the low elevation of the borings. Borings B4 and B5 are at lower elevations, 4.1 and 3.5 feet above mean sea level (MSL), respectively, than are borings B1a, B1b, and B2, greater than 9 feet above MSL. While borings B1a, B1b, and B2 penetrated mounded groundwater moving downward through the sludge, borings B4 and B5 most likely penetrated upward moving brackish groundwater that has become contaminated by contact with sludge.

3.3 TOTAL AND FREE CYANIDE IN LEACHATE AND GROUNDWATER

Leachate in contact with the sludge in the shallow hand-augered borings completed for this investigation was sampled and analyzed for total and free cyanide content by Martin-Marietta Environmental Systems. The results of these analyses are presented in Appendix 4A. The total cyanide concentration in three leachate samples collected within the impounds (borings B2, B4, and B5) ranged from 85 to 124 mg/l, averaging 105 mg/l. The free cyanide concentration in the same three samples ranged from 0.33 to 2.4 mg/l, averaging 1.1 mg/l.

At a distance of about 20 feet outside the dike, the total cyanide concentration in groundwater samples from borings B6 and B7 decreased to 62 and 49 mg/l, respectively, while the free cyanide concentration of 2.3 and 0.55 mg/l, respectively, remained at about the same levels as inside the impounds.

Although the number of samples (n) is small for statistical purposes, evaluation of the cyanide concentrations in leachate samples collected inside the impounds (n=3) compared to those collected outside (n=2) indicates that, even though there is a significant decrease in the total cyanide concentration as the groundwater migrates out of the impounds, the free cyanide concentration remains unchanged (see Appendix 4B). This finding agrees with the reported fate of cyanide in water (see section 4.2 and Figure 9).

3.4 TOTAL AND FREE CYANIDE IN SURFACE WATER

During the May 15-16, 1986 site investigation, a grab sample of the Rahway River was collected at the bank closest to borings B6 and B7 (see Figure 8). Analysis of that grab sample indicated 2.0 mg/l total cyanide and 0.084 mg/l free cyanide. Analysis of a grab sample of surface water collected from Cross Creek near the front gate of the impound area (see Figure 8) indicated 0.37 mg/l total cyanide and 0.012 mg/l free cyanide.

Based on these preliminary analyses of surface water, Cyanamid personnel applied a surface water transport model to the Rahway River to evaluate the potential impacts of cyanide releases. The model used was the Quirk, Lawlar, Metuski one-dimensional, steady-state, conservative transport model that was developed for the Arthur Kill, Newark Bay, Raritan River, and Raritan Bay System. Based on the outcome of this modeling, assuming a free cyanide concentration of 0.084 mg/l in a discharge of 17,000 cubic feet per day, no adverse impact on the Rahway River was predicted.

To confirm the absence of an impact on the Rahway River a follow-up surface-water sampling program was conducted in October 1986. Figure 8 shows the locations of surface water sampling points in the Rahway River, Cross Creek, and Marsh Creek. Each station was sampled at both high (except stations 7 and 8) and low tides. Appendix 5 presents a table correlating sampling numbers, sampling locations, and results of total and free cyanide analyses. Appendix 6 presents the field data on total water depth, sampling depth, water temperature, salinity, and specific conductivity.

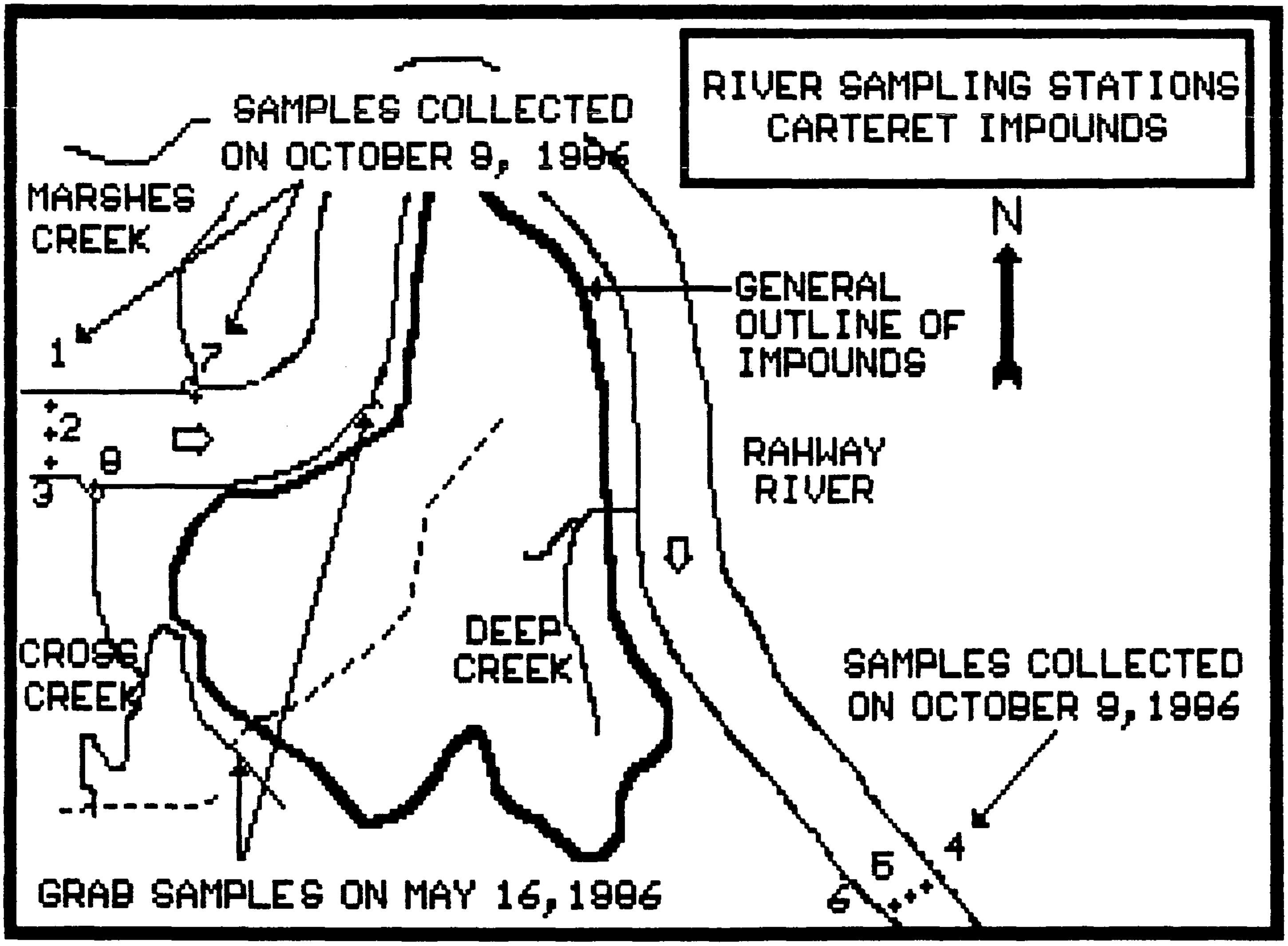

Figure 8. Approximate locations of stations for surface-water samples collected on May 16 and October 9, 1986 near the Carteret Impounds.

The results indicate that both total and free cyanide were below the detection limit of 0.025 mg/l in all samples except one. Sample No. L8, collected upstream of the Carteret Impounds in the mouth of Cross Creek (at low tide), was reported to have a total cyanide concentration of 0.032 mg/l and a free cyanide concentration of 0.032 mg/l. The analyses of duplicate and blank samples indicate the sampling technique was valid.

4.0 ASSESSMENT OF POTENTIAL ENVIRONMENTAL AND HEALTH RISKS

4.1 ENVIRONMENTAL AND HEALTH CONCERNS

The major concern for the release of cyanide from the impounds is the potential effect on aquatic life in the Rahway River and tributaries. Cyanide that may be released from the impounds does not present a risk to human health via the drinking water exposure route since no water supply intake is downgradient of the impounds.

In freshwater aquatic environments free cyanide is toxic to many fish in the range of 0.05 to 0.1 mg/l and is rapidly fatal to most fish species at concentrations much above 0.2 mg/l (4). The EPA water-quality criteria for cyanide was established at 0.005 mg/l (4). However, the surface waters in the vicinity of the Carteret Impounds are brackish with observed salinities above 15 parts per thousand. For comparison, sea water off New Jersey has a salinity of approximately 33 parts per thousand (6). EPA (4) reports that the effects of cyanide on marine life have not been investigated adequately to determine separate water-quality criteria. Due to the generally alkaline nature of marine waters, the toxicity of cyanide should be less than in fresh waters (4). Thus EPA (4) states that the freshwater criterion for cyanide was applied to marine aquatic life to provide a margin of safety and compensate for the lack of specific data.

The State of New Jersey water-quality criteria are based on a classification of surface waters. Due to the salinity of the Rahway River and its tributaries in the vicinity of the Carteret Impounds (ranging from 15.0 to 21.5 parts per thousand on October 9, 1986), these surface water bodies should be classified as saline estuaries, or the "SE" classification (see Title 7, Chapter 9, section 7:9-4.4). The water-quality criteria applied to the SE classification contains no criteria for cyanide (ibid., section 7:9-4.14(c)).

The standards pursuant to the New Jersey Pollutant Discharge Elimination System (NJPDES), however, establishes a water-quality criteria of 0.03 mg/l free cyanide for protection of aquatic life in salt water (Title 7, Chapter 14, section 7:14a, Appendix F, Values for Determination of NJPDES Permit Toxic Effluent Limits). The results of the Rahway River sampling program completed in October of 1986 indicated free cyanide concentrations in the Rahway were below the 0.03 mg/l level.

4.2 CONCEPTUAL MODEL OF THE FATE OF CYANIDE IN WATER AT THE CARTERET IMPOUNDS

The fate of cyanide that is released in leachate leaving the Carteret Impounds will be dominated by three processes: dilution, volatilization, and biodegradation. These processes operate to reduce the concentration of both total and free cyanides in water as it moves from the impounds, through the groundwater, and into the surface water. Figure 9 presents a graphical description of the fate of cyanide in groundwater and surface water.

Dilution of leachate occurs as it flows from the impounds into the Rahway River. The dilution rate of leachate in the Rahway River has been estimated to average more than 300 times (see Appendix 1).

Callahan et al. (5) report that in waters with a pH less than 10, almost all of the free cyanide is in the form HCN (hydrogen cyanide) which is highly volatile. Therefore, HCN will volatilize from surface water at a relatively high rate and from leachate and contaminated groundwater at a lower rate. The volatilization will decrease the concentration of free cyanide in the water. This results in the release of cyanides that are complexed with metals (M:CN in Figure 9) due to the shift in the equilibrium between the free and complexed cyanide (the arrow in Figure 9 points from M:CN towards HCN (aqueous)). The outcome of this process is the decrease of total cyanide concentration.

Biodegradation of cyanide occurs in all organisms where the cyanide concentration is below toxic levels (5). Due to the higher concentrations and lower levels of biological activity, biodegradation of cyanide is a limited process in the groundwater. Biodegradation may only occur along the fringes of the plume of contamination where dispersion and diffusion have decreased the cyanide concentration sufficiently to allow microorganisms to become active. As the contaminated groundwater discharges into the surface water where dissolved oxygen and nutrients are more readily available, biodegradation becomes a major process in decreasing cyanide concentration. The high dilution rate in the Rahway River decreases the concentration of cyanide to levels that allow biological degradation to proceed.

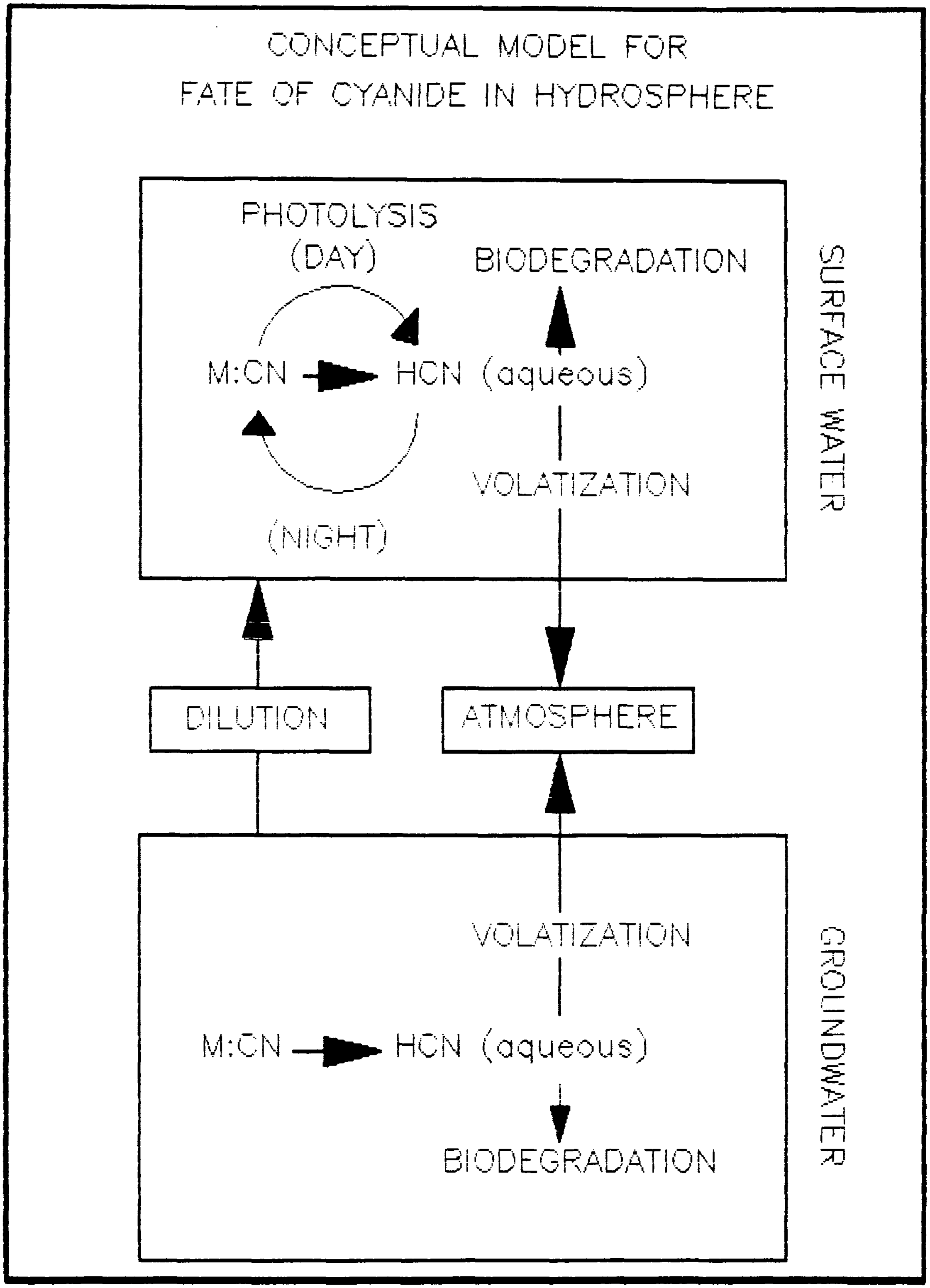

Figure 9. Conceptual model of the fate of cyanide in water at the Carteret Impounds.

5.0 CONCLUSIONS

5.1 POTENTIAL IMPACTS ON SURFACE-WATER QUALITY

Based on the results of the cyanide analyses of samples collected on October 9, 1986, the Carteret Impounds present no detectable adverse impact relative to total or free cyanide concentrations in the Rahway River (using a detection limit of 0.025 mg/l). Although cyanide contaminated leachate appears to be migrating from the impounds, the magnitude of dilution in the Rahway River and the natural loss of cyanide via biodegradation and volatilization apparently are sufficient to decrease the cyanide concentration to below 0.025 mg/l at the river sampling stations.

However, relatively low concentrations of total and free cyanide were detected in Cross Creek. On May 16, 1986, a sample from a tributary to Cross Creek near the front gate to the impound area was found to have total and free cyanide concentrations of 0.37 and 0.012 mg/l, respectively. A resampling of Cross Creek at its mouth near the Rahway River at low tide on November 17, 1986 (Sample No. L8) showed a total cyanide concentration of 0.032 mg/l, which was made up solely of free cyanide. Although the concentrations found in the two samples can not be compared on a statistical basis, it appears that degradation and dilution effectively reduce the total cyanide concentration from the tributary near the front gate to the mouth of Cross Creek.

The municipal landfill on the west side of Cross Creek may contribute cyanide to Cross Creek. However, the amount of cyanide contributed by the adjacent municipal landfill can not be estimated at this time.

5.2 POTENTIAL IMPACTS ON GROUNDWATER QUALITY

Based on the conceptual model of the groundwater system, the contamination of groundwater probably is limited to a lens-shaped zone beneath the impounds. The groundwater flow within the underlying Brunswick Formation should be upward, discharging into the surface water. This upward flow out of the Brunswick, in combination with the probable density contrast between the Brunswick groundwater and the contaminated groundwater originating in the impounds, should prevent contamination from migrating into the Brunswick. All contaminated groundwater should be discharging into the adjacent surface water.

6.0 RECOMMENDATIONS

The remaining questions concerning the potential risk from releases of cyanide contamination at the Carteret Impounds involve clarification of the applicable water-quality criteria for cyanide, confirmation of the extent of groundwater contamination, and determination of whether the reportable quantity for cyanide salts may be exceeded.

6.1 APPLICABILITY OF WATER-QUALITY CRITERIA

Based on the discussion in section 4.1 above, it is not clear whether an applicable water-quality criteria exists for the Rahway River and its tributaries. Based on our interpretations, the New Jersey water-quality criteria do not contain a cyanide limit for saline estuaries. However, the NJPDES water-quality criteria of 0.03 mg/l free cyanide is for salt water. Finally, the EPA water-quality criteria of 0.005 mg/l was established on the basis of the toxicity of cyanide to freshwater species, and it is not clear how the EPA criteria applies to the Rahway River and its tributaries. Therefore, it is recommended that a legal opinion be made concerning what, if any, is the applicable water-quality criteria for cyanide in the surface waters.

6.2 CONFIRMATION OF THE EXTENT OF GROUNDWATER CONTAMINATION

The extent of groundwater contamination will be investigated as a result of the groundwater monitoring program required by the New Jersey Department of Environmental Protection (DEP) as part of the pending State facilities permit for discharge to groundwater.

The DEP recommended the installation of four wells with a 20-foot screened interval with the top of the screen set at the water table.

However, this recommended design would not provide data on the vertical hydraulic gradients that are important to the question of direction of flow out of the Brunswick. Therefore, it is recommend that paired wells be used with one well screened over a shallow interval and the other screened over a deeper interval. Data obtained at the two depths will provide information on both the vertical and horizontal components of the hydraulic gradient.

The 20-foot screened interval provides only an average value for the concentration of constituents in the groundwater. If significant contamination is found, little interpretation is possible concerning its extent or rates of attenuation. The use of the paired wells screened over a smaller interval at different depths will provide better information concerning the extent of downward migration of contamination.

The original placement of downgradient wells is suitable for monitoring releases from the impounds. However, the original placement of the "background" well on the impound-side of Cross Creek is not anticipated to provide true background quality. Due to the mounding of groundwater within the impounds, there is a possibility that groundwater from the impounds will flow westward and discharge into Cross Creek (which may explain the detection of cyanide in Cross Creek near the front gate). Therefore, the original placement of the "background" well could intercept potentially contaminated groundwater.

It is recommended that a fifth pair of wells be added to the monitoring system and be located on the west side of the tributary of Cross Creek near the front gate. This pair of wells should intercept groundwater originating outside of the impounds. Figure 10 shows the proposed locations of the five pairs of wells (numbered 1S through 5S and 1T through 5T). Specifications for the shallow and deep (referred to as "Triassic" wells) wells are presented in Figures 11 and 12.

Also recommended as part of the groundwater monitoring program is the testing of each monitoring well to estimate the hydraulic conductivity of the subsurface. The bailer test method can be employed to determine an estimate of the hydraulic conductivity in the vicinity of the screened interval for each well.

6.3 NOTIFICATION REQUIREMENTS

The reportable quantity (RQ) for soluble cyanide salts is the release of 10 pounds or more in any 24-hour period. At this time, there is insufficient data to determine the rate of release of soluble cyanide salts (i.e., total cyanide concentration) in leachate migrating from the impounds. The groundwater monitoring program will provide additional data relating to the determination of whether the RQ is being exceeded.

After the first round of groundwater analyses has been completed, the average concentration of total cyanide can be calculated. The data on hydraulic conductivity and hydraulic gradient obtained from the groundwater monitoring program will allow modeling of the migration of leachate out of the impounds and estimation of the total mass of cyanide being released in a 24-hour period.

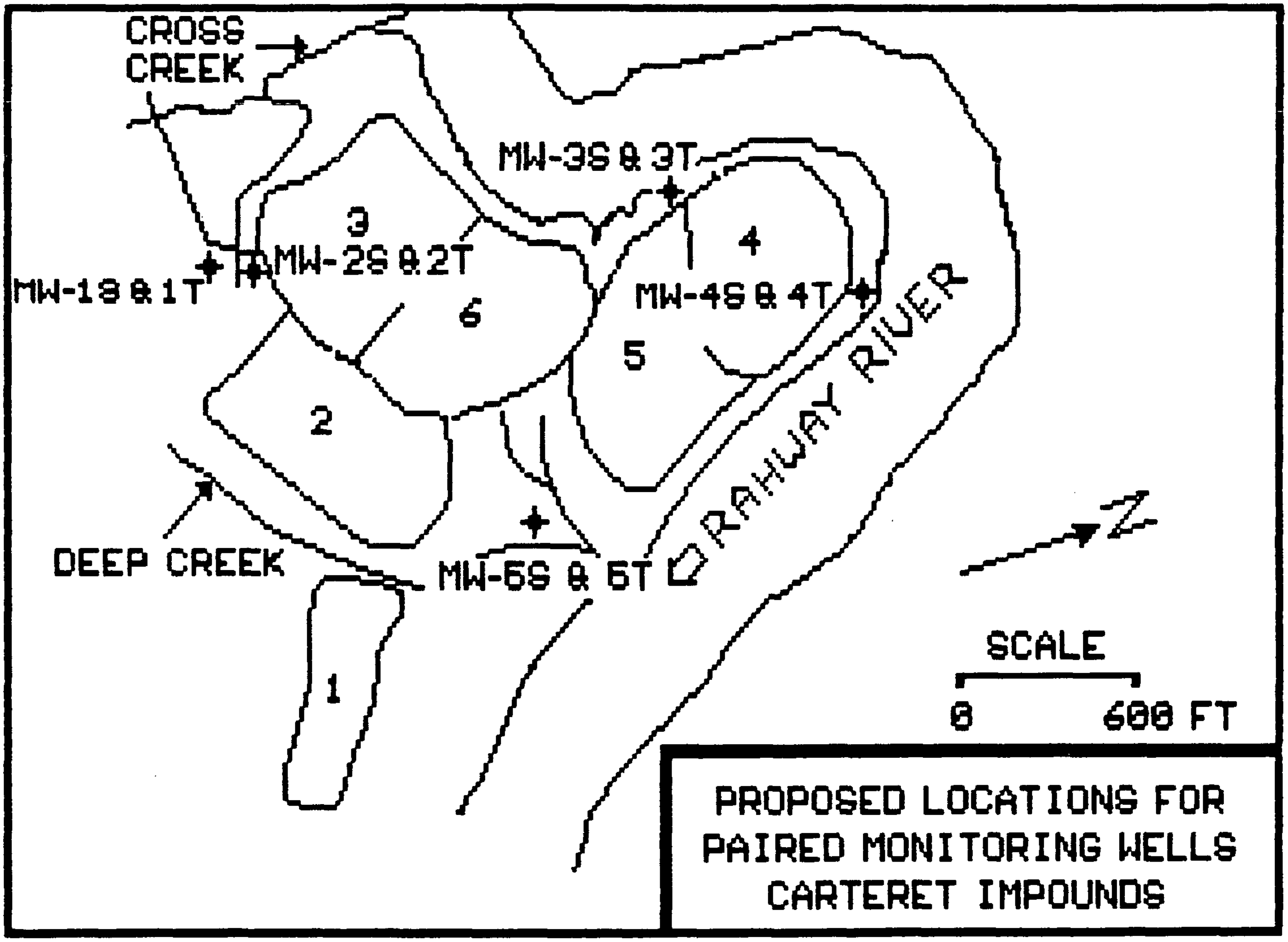

Figure 10. Proposed locations of monitoring wells for the Carteret Impounds.

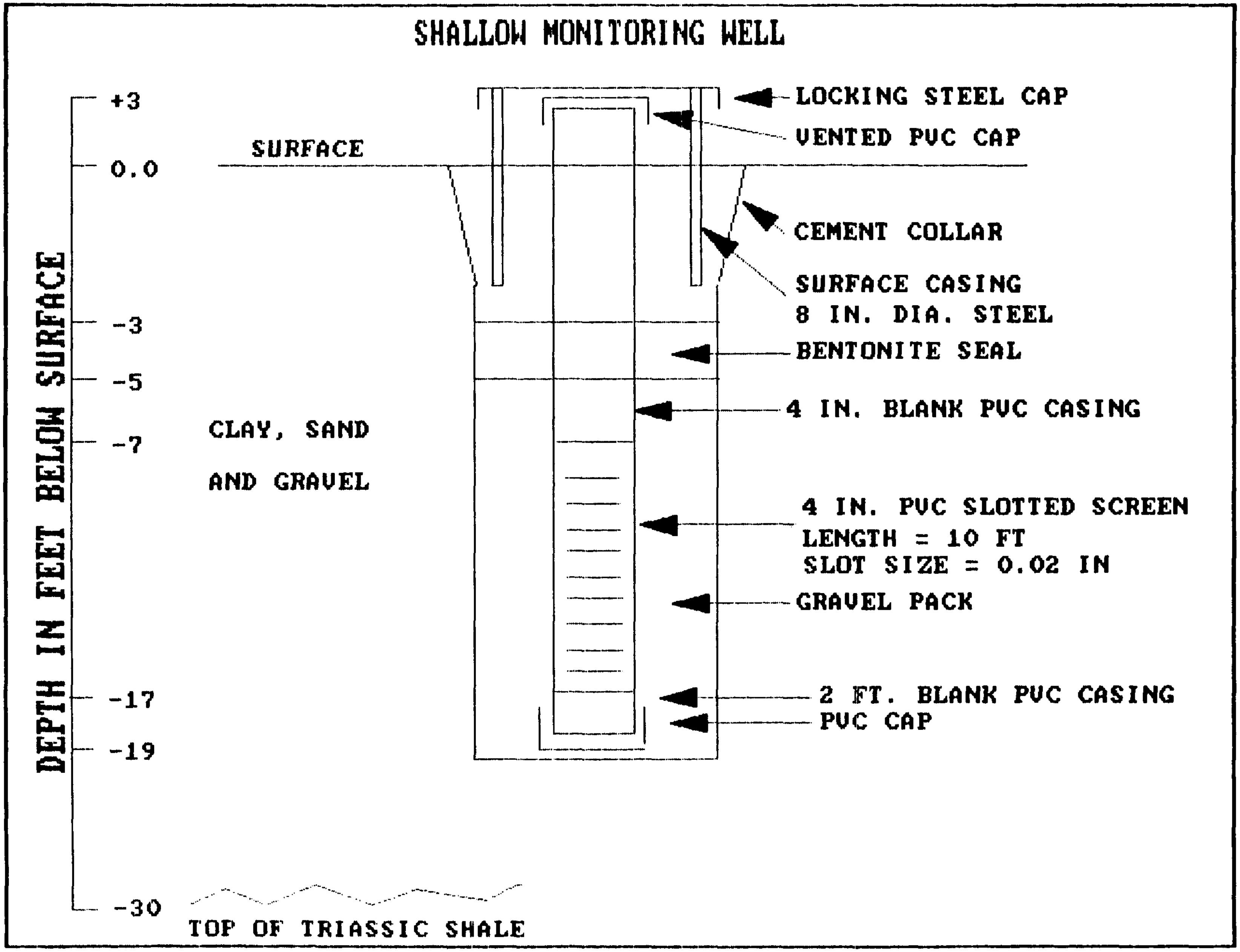

Figure 11. Specifications for the proposed shallow groundwater monitoring wells at the Carteret impounds.

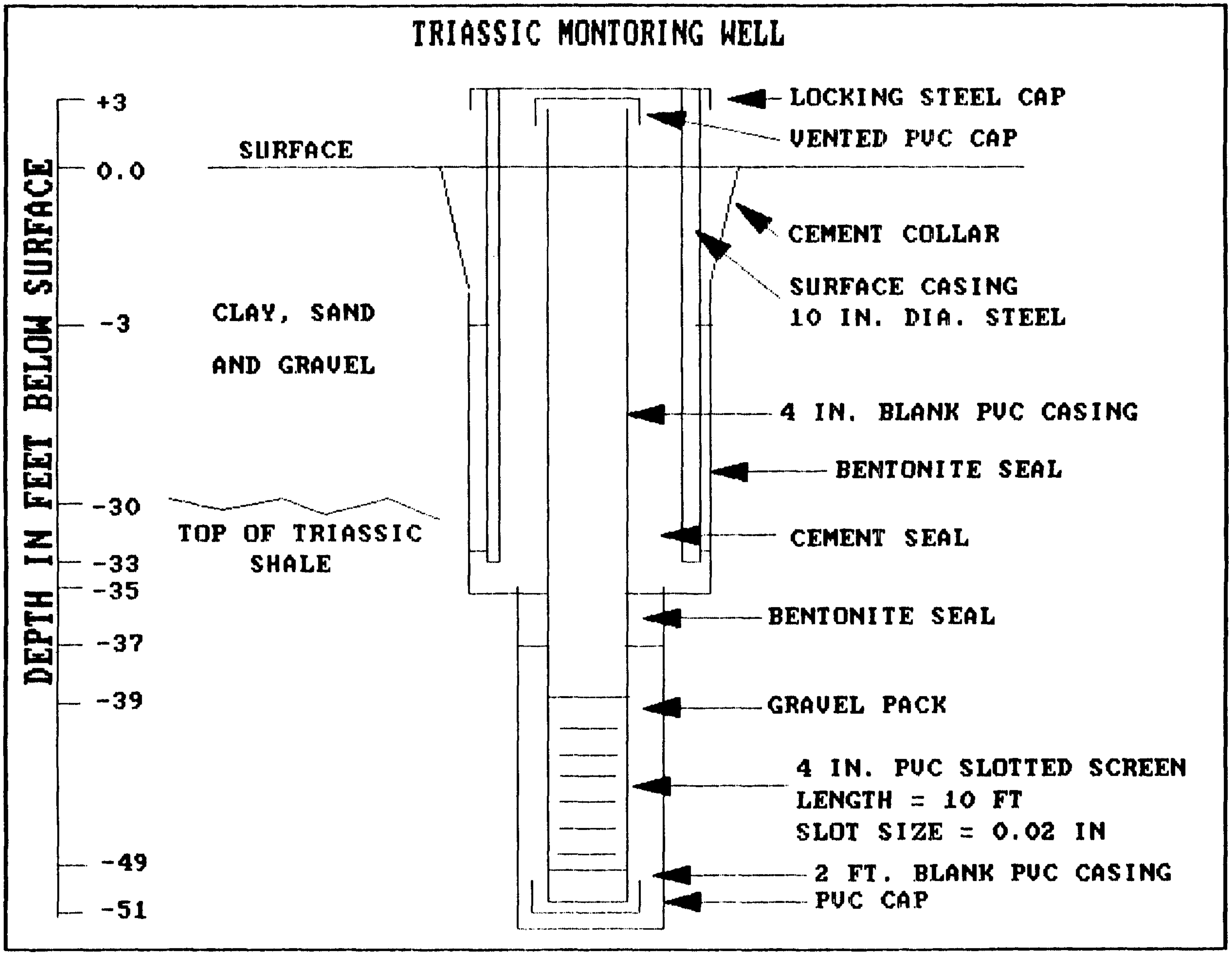

Figure 12. Specifications for the proposed deeper "Triassic"groundwater monitoring wells at the Carteret Impounds.

7.0 REFERENCES

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APPENDIX 1

EVALUATION FORM FOR ASSESSMENT
OF ACCIDENTAL RELEASES TO GROUNDWATER AND SURFACE WATER
CARTERET IMPOUNDS
CARTERET, NEW JERSEY

PREPARED BY HYDROSYSTEMS, INC.
JANUARY 16, 1987

INACTIVE SITE SURVEY 1/16/87
PHASE 1
PRELIMINARY EVALUATION FORM

I. Facility Information

1. Plant Name- Carteret Impounds (Warners Plant)

2. Address- Middlesex County

3. Location - Latitude 40 Deg. 36 Min.
Longitude 74 Deg. 12 Min. 50 Sec.

Quad- Aurthur Kill, NY-NJ, PR 1981

4. Plant Description- Production of alum and pesticides

5. Facility Identification- Inactive sludge impound

6. Facility Location on Plant- On south side of Rahway River across from plant site.

7. Year Facility First Used- 1939

8. Year Facility Last Used- 1973

9. Estimated Waste Volume- 1,940,000 tons

10. Waste Types- Alum sludge, yellow prussiate soda (YPS)

11. Facility Design

Liner Type- None

12. Closure Procedure

Cover Liner Type- None

13. Monitoring

Groundwater- None

Surface Water- Some grab sampling conducted

II. Hydrologic Budget

RECHARGE = PRECIPITATION - EVAPOTRANSPIRATION - RUNOFF

1. Precipitation, Annual Average- 42 in/yr

Source- (3) For period 1933 to 1972

2. Potential ET, Annual Average- 27 in/yr

   Source- (5)

3. Runoff, Annual Average- 4 to 6 in/yr

   Source- (10) gives estimate for runoff on grassy sandy soil with 2% to 7% slopes of 0.1 to 0.15 of precipitation.

4. Recharge, Annual Average- 9 to 11 in/yr

   Source- (See equation at beginning of this section.)

III. Estimated Leachate Production

Estimated Average Leachate Production-

Estimated infiltration (from sec. II.4), I = 1.0 ft/yr= 0.0025 ft/d
Area of landfill, A = 110 acres = 4,790,000 sft
Estimated leachate production, Q= AxI = 12,000 cft/d

IV. Hydrogeology

1. Estimated Groundwater Flow Direction at Facility-

   North and northeast to Rahway River
   Source- Topo map and water levels in shallow hand borings

2. Estimated Gradient- 0.001 Source- Estimated

3. Estimated Depth to Water Table- 0
   Source- (4)

4. Type of Unsaturated Zone Material- N/A

5. Estimated Permeability of Unsaturated Zone- N/A

6. Type of Aquifer Material- Alluvial silt, sand and gravel and fractured shale of the Brunswick Formation.
   Source- (4)

7. Thickness of Aquifer- Alluvium is about 20 to 30 ft thick

   Source- (4)

8. Estimated Permeability of Aquifer- 0.3 ft/d

   Source- (4)

9. Distance from Downgradient
   Facility Edge to Property Boundary- 0

   Source- site plan in (4)

10. Distance from Downgradient Facility
    Edge to Nearest Downgradient Well- None downgradient

    Source- (4)

    Note- In (3) the closest water supply well identified was 5,000 ft to the southwest in Carteret. Considering the groundwater flow system, the groundwater beneath the site would continue to flow towards and discharge into the surface water, e.g., the Rahway River.

11. Type of Well- N/A

V. Surface Water Hydrology

1. Name of Nearest Surface Water- Rahway River

   Source- Topo map

2. Distance to Nearest Surface Water- 0

   Source- Topo map and site plan in (4)

3. Estimated Average Flow Rate- 47 cfs

   Source- (1) measured at Rahway, NJ, for period 1922 to 1983

4. Estimated Low Flow Rate- 0

   Source- (1), but tidally influenced

5. Distance to Nearest
   Downstream Water Supply Intake- None

   Source- Topo map

VI. Waste Characteristics

1. Waste Constituent of Concern- Cyanide

Source- files

2. Reason for Concern-

Cyanide is toxic to humans only if taken in high, single doses. The EPA reports that a dose of 10 mg or less of cyanide will be converted readily in the human body to thiocyanate, which is a much less toxic form. The EPA calculated a threshold limit for cyanide of 19 mg/l below which no toxic response should be exhibited. In addition, in water with a pH of 8.5, cyanide is readily converted to cyanate which also is much less toxic. Since cyanide is not a commonly occurring constituent in drinking water, the EPA elected to omit cyanide from the primary and secondary drinking water regulations. (6)

However, cyanide is toxic to aquatic life at much lower levels than in man due to the inability of aquatic life to convert cyanide to a less toxic form. The EPA water quality criteria establish a limit of 0.005 mg/l (5 ug/l) for aquatic life. EPA reports that cyanide is acutely toxic to most freshwater fish species at concentrations ranging from 0.05 to 0.2 mg/l (50 to 200 ug/l). However, no data is available for the toxicity of cyanide in saline water. (7)

Cyanide forms complexes with metals in aqueous solution. The stability of the metallocyanide complexes is dependent on the metal. Cyanide complexes with zinc and cadmium are not stable, rapidly dissociating into hydrocyanic acid in near neutral waters. The iron cyanides are very stable, but undergo photodecomposition, releasing free cyanide. At night, the iron cyanide may reform again. (7)

In addition, cyanide (and soluble cyanide salts) is designated a hazardous substance and assigned a reportable quantity (RQ) of 10 pounds in 40 CRF 302.4, notification requirements under CERCLA.

2. Solubility- Cyanide is infinitely soluble in water.

Source- (8)

3. Mobility in Groundwater as Retardation Coefficient-

Cyanide is a conservative constituent in groundwater, behaving in a similar manner as chloride. The retardation coefficient is 1.0.

Source- (7)

4. Persistence as Half-Life- Cyanide is stable over a wide range of conditions although all organisms can biodegrade cyanide. HCN also is highly volatile and should readily volatilize from water. To be conservative, cyanide is assumed stable.

   Source- (7), (9)

VII. Preliminary Evaluation of Pathway and Dilution Rates

1. Likely Potential Pathway- Groundwater to Rahway River

2. Estimated Dilution Rate in the Rahway River.

   A. Estimated leachate production = 12,000 cft/d.

   B. Average flow rate of Rahway River = 47 cfs
   = 4.1 E 06 cft/d.

   C. Estimated average dilution rate of leachate by Rahway River = greater than 300 times.

VIII. Hydrogeologic Description

The inactive alum impoundments at Carteret are located on the boundary between the Piedmont and Coastal Plain physiographic provinces. Surficial deposits consist of about 20 to 40 feet of Quaternary alluvium, composed of interbedded sand, gravel, and clay, with buried peat and organic rich horizons. The alluvium was deposited in a salt-march environment. (2), (4) Bedrock underlying the alluvium is the Triassic-age Brunswick Formation consisting of bedded shales, mudstones and sandstones which attain a maximum thickness of 6,000 to 8,000 feet in New Jersey. (2)

On-site test borings indicated that bedrock was from 16 to 20 feet below the base of the impoundments. The intervening alluvial sediment consisted of 4 to 6 feet of meadow mat directly underlying the impoundments, and 7 to 9 feet of silt, and minor amounts of sand, gravel, and clay. (4)

The Brunswick Formation is the major source of groundwater in the region with wells producing from depths of about 150 feet. The groundwater in the Brunswick occurs in fractured shale and may be locally high in sulfate and hardness due to the presence of evaporite deposits. (4)

From available information, no water well intercepts the groundwater directly beneath the inactive impoundments. In fact, it is reported that the groundwater underlying the impoundments may be brackish due to natural saltwater intrusion (4).

IX. Source Reference List

Source No.	Reference
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2.	Nemickas, B., 1976, Geology and Ground-Water Resources of Union County, New Jersey, U.S. Geological Survey, Water Resources Investigations No. 76-73.
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4.	M. Disko Associates, 1982, Preliminary Report of Test Borings and Dike Evaluation at the Warners Plant Impounds, American Cyanamid Company, January 1982.
5.	Geraghty, J.J., et al., 1973, Water Atlas of the United States, Water Information Center, Soyosett, NY.
6.	U.S. Environmental Protection Agency, 1976, National Interim Primary Drinking Water Regulations, EPA 570/9-76-003.
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9.	Hem, J.D., 1970, Study and Interpretation of the Chemical Characteristics of Natural Waters, U.S. Geological Survey, Water Supply Paper 1473.
10.	Fenn, D.G., K.J. Hanley, and T.V. DeGeare, 1975, Use of the Water Balance Method for Predicting Leachate Generation from Solid Waste Disposal Sites, EPA/530/SW-168, U.S. Environmental Protection Agency, Cincinnati, Ohio.

APPENDIX 2

FIELD DATA FOR HAND-AUGERED BORINGS
CARTERET IMPOUNDS
AMERICAN CYANAMID COMPANY
CARTERET, NEW JERSEY
COLLECTED BY HYDROSYSTEM, INC.
MAY 15-16, 1986

APPENDIX 2

FIELD DATA FOR HAND-AUGERED BORINGS
CARTERET IMPOUNDS
AMERICAN CYANAMID COMPANY
CARTERET, NEW JERSEY
COLLECTED BY HYDROSYSTEM, INC.
MAY 15-16, 1986

BORING NO.	ESTIMATED ELEVATION OF TOP (Ft above MSL)	ESTIMATED ELEVATION OF WATER TABLE (Ft above MSL)	FIELD pH OF GROUNDWATER (pH Units) (NOTE 1)	FIELD SPECIFIC CONDUCTIVITY (Micromhos/cm) (NOTE 2)
B1a	9.7	4.4	NR	1,100
B1b	9.2	4.7	7	750
B2	13.6	10.9	7	2,120
B3	12.5	NR	NR	NR
B4	4.1	2.8	7	32,000
B5	3.5	2.8	7	18,500
B6	4.0	3.5	8	19,500
B7	3.0	2.5	8	19,000

NR = NOT RECORDED

NOTE 1 = ESTIMATED IN FIELD USING EM SCIENCE "colorpHast" BRAND pH INDICATOR STRIPS (pH RANGE 0-14, CATALOG NO. 9590).

NOTE 2 = MEASURED IN FIELD WITH A YSI MODEL 33 CONDUCTIVITY METER.

APPENDIX 3

LABORATORY ANALYSES FOR EP TOXICITY
AND FREE AND TOTAL CYANIDE CONCENTRATIONS
FOR HAND-AUGERED BORINGS
CARTERET IMPOUNDS
AMERICAN CYANAMID COMPANY
CARTERET, NEW JERSEY
COLLECTED BY HYDROSYSTEM, INC.
MAY 15-16, 1986

APPENDIX 3

LABORATORY ANALYSES FOR EP TOXICITY
AND FREE AND TOTAL CYANIDE CONCENTRATIONS
IN SLUDGE FROM HAND-AUGERED BORINGS
CARTERET IMPOUNDS
AMERICAN CYANAMID COMPANY
COLLECTED BY HYDROSYSTEM, INC.
MAY 15-16, 1986

PARAMETER	METHOD OF ANALYSIS	DETECTION LIMIT (MG/L)	EP TOX. CRITERIA (MG/L)	SAMPLE NO. BORING NO. IMPOUND. NO.	C1 B1a 4	C2 B2 5	C2 B2 5	C3 B3 6	C4 B4 3	C4 B4 3	C5 B5 2
	(NOTE 1)						(DUPLICATE)			(DUPLICATE)	
ARSENIC	ICP	0.2	5.0		BDL	BDL	NA	BDL	BDL	BDL	BDL
BARIUM	ICP	0.2	100.0		BDL	BDL	NA	BDL	BDL	BDL	BDL
CADMIUM	ICP	0.05	1.0		BDL	BDL	NA	BDL	BDL	BDL	BDL
CHROMIUM	ICP	0.05	5.0		BDL	BDL	NA	BDL	BDL	BDL	BDL
LEAD	ICP	0.2	5.0		BDL	BDL	NA	BDL	BDL	BDL	BDL
MERCURY	CV	0.0003	0.2		BDL	BDL	BDL	BC	BC	NA	BDL
SELENIUM	ICP	0.2	1.0		BDL	BDL	NA	BDL	BDL	BDL	BDL
SILVER	ICP	0.05	5.0		BDL	BDL	NA	BDL	BDL	BDL	BDL

UNITS FOR CYANIDE VALUES IN MG/KG

TOTAL CYANIDE (NOTE 3)	0.5	NONE	683	452	NA	3660	437	NA	433
FREE CYANIDE (NOTE 4)	0.5	NONE	14	18	NA	103	38	NA	9

NOTE 1: ICP = INDUCTIVELY COUPLED PLASMA SPECTROMETRY
CV = COLD VAPOR ATOMIC ABSORPTION SPECTROSCOPY

NOTE 2: BDL = BELOW DETECTION LIMIT
BC = BELOW EP TOXICITY CRITERIA
NA = NOT ANALYZED

NOTE 3: METHOD 335.2 OF STANDARD METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTE
EPA-600/4-79-020, REVISED MARCH 1983.

NOTE 4: METHOD 412 OF STANDARD METHODS, 16TH EDITION, 1985.

APPENDIX 4A

LABORATORY ANALYSES OF GROUNDWATER SAMPLES
FOR FREE AND TOTAL CYANIDE CONCENTRATIONS
FROM HAND-AUGERED BORINGS
CARTERET IMPOUNDS
AMERICAN CYANAMID COMPANY
CARTERET, NEW JERSEY
COLLECTED BY HYDROSYSTEM, INC.
MAY 15-16, 1986

APPENDIX 4B

STUDENT'S T-TEST ON CYANIDE MEANS
BETWEEN BORINGS INSIDE THE IMPOUNDS (B2, B4, & B5) AND
BORINGS OUTSIDE THE IMPOUNDS (B6 & B7)

APPENDIX 4A

LABORATORY ANALYSES OF GROUNDWATER SAMPLES
FOR FREE AND TOTAL CYANIDE CONCENTRATIONS
FROM HAND-AUGERED BORINGS
CARTERET IMPOUNDS
AMERICAN CYANAMID COMPANY
COLLECTED BY HYDROSYSTEM, INC.
MAY 15-16, 1986

PARAMETER	METHOD OF ANALYSIS	DETECTION LIMIT (MG/L)	SAMPLE= BORING= IMPOUND=	CART-2 B2 5	CART-4 B4 3	CART-5 B5 2	CART-6 B6 (NOTE 3)	CART-7 B7 (NOTE 3)	BLANK
							(MG/L)		
TOTAL CYANIDE	(NOTE 1)	0.005		85.00	124.00	105.00	62.00	49.00	0.013
FREE CYANIDE	(NOTE 2)	0.005		0.33	2.40	0.50	2.30	0.55	0.007

NOTE 1: METHOD 335.2 OF STANDARD METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTE EPA-600/4-79-020, REVISED MARCH 1983.

NOTE 2: METHOD 412 OF STANDARD METHODS, 16TH EDITION, 1985.

NOTE 3: BORINGS B6 AND B7 ARE ABOUT 20 FEET OUTSIDE OF IMPOUND NO. 4.

APPENDIX 4B

STUDENT'S T-TEST ON CYANIDE MEANS
BETWEEN BORINGS INSIDE THE IMPOUNDS (B2, B4, & B5) AND
BORINGS OUTSIDE THE IMPOUNDS (B6 & B7)

	INSIDE IMPOUNDS		OUTSIDE IMPOUNDS					
PARAMETER	AVERAGE INSIDE (N=3)	VARIANCE INSIDE	AVERAGE OUTSIDE (N=2)	VARIANCE OUTSIDE	T-TEST (CALC.)	DEGREES OF FREEDOM	ARE MEANS EQUAL	LEVEL OF SIGNIFICANCE
TOTAL CYANIDE	104.67	253.56	55.50	42.25	4.78	4	NO	0.005
FREE CYANIDE	1.08	0.88	1.43	0.77	-0.42	4	YES	

APPENDIX 5

RAHWAY RIVER SAMPLING PROGRAM
SUMMARY OF ANALYTICAL RESULTS
FOR TOTAL AND FREE CYANIDE
IN SURFACE WATER
NEAR THE CARTERET IMPOUNDS
COLLECTED BY HYDROSYSTEMS, INC.
OCTOBER 9, 1986

APPENDIX 5

RAHWAY RIVER SAMPLING PROGRAM
SUMMARY OF ANALYTICAL RESULTS
FOR TOTAL AND FREE CYANIDE
IN SURFACE WATER
NEAR THE CARTERET IMPOUNDS
COLLECTED BY HYDROSYSTEMS, INC.
OCTOBER 9, 1986

HYDROSYSTEMS' SAMPLE ID NUMBER	SAMPLING LOCATION DESCRIPTION	CYANIDE CONCENTRATION (IN MG/L) TOTAL	FREE
THE FOLLOWING SAMPLES WERE COLLECTED JUST BEFORE HIGH TIDE RIVER FLOW IS INLAND			
H1	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM FAR BANK	BDL	BDL
H2	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER MID STREAM	BDL	BDL
H3	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM NEAR BANK	BDL	BDL
H4	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM FAR BANK	BDL	BDL
H5	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER MID STREAM	BDL	BDL
H6	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM NEAR BANK	BDL	BDL
H16	DUPLICATE SAMPLE OF NO. H6	BDL	BDL
H20	FIELD BLANK	BDL	BDL

BDL = BELOW DETECTION LIMIT OF 0.025 MG/L

APPENDIX 5 (CONTINUED)

RAHWAY RIVER SAMPLING PROGRAM
SUMMARY OF ANALYTICAL RESULTS
FOR TOTAL AND FREE CYANIDE
IN SURFACE WATER
NEAR THE CARTERET IMPOUNDS
COLLECTED BY HYDROSYSTEMS, INC.
OCTOBER 9, 1986

HYDROSYSTEMS' SAMPLE ID NUMBER	SAMPLING LOCATION DESCRIPTION	CYANIDE CONCENTRATION (IN MG/L) TOTAL	FREE
THE FOLLOWING SAMPLES WERE COLLECTED JUST BEFORE LOW TIDE RIVER FLOW IS SEAWARD			
L1	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM FAR BANK	BDL	BDL
L2	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER MID STREAM	BDL	BDL
L12	DUPLICATE SAMPLE OF NO. L2	BDL	BDL
L3	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM NEAR BANK	BDL	BDL
L4	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM FAR BANK	BDL	BDL
L5	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER MID STREAM	BDL	BDL
L15	DUPLICATE SAMPLE OF NO. L5	BDL	BDL
L6	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM NEAR BANK	BDL	BDL
L7	UPSTREAM OF IMPOUNDS IN MARSH CREEK FAR BANK OF RAHWAY RIVER	BDL	BDL
L8	UPSTREAM OF IMPOUNDS IN CROSS CREEK NEAR BANK OF RAHWAY RIVER	0.032	0.032
L20	FIELD BLANK	BDL	BDL

BDL = BELOW DETECTION LIMIT OF 0.025 MG/L

APPENDIX 6

RAHWAY RIVER SAMPLING PROGRAM
SUMMARY OF FIELD DATA ON TOTAL AND SAMPLING DEPTH,
TEMPERATURE, SALINITY, AND SPECIFIC CONDUCTIVITY
IN SURFACE WATER
NEAR THE CARTERET IMPOUNDS
COLLECTED BY HYDROSYSTEMS, INC.
OCTOBER 9, 1986

APPENDIX 6

RAHWAY RIVER SAMPLING PROGRAM
SUMMARY OF FIELD DATA ON TOTAL AND SAMPLING DEPTH,
TEMPERATURE, SALINITY, AND SPECIFIC CONDUCTIVITY
IN SURFACE WATER
NEAR THE CARTERET IMPOUNDS
COLLECTED BY HYDROSYSTEMS, INC.
OCTOBER 9, 1986

HYDROSYSTEMS' SAMPLE ID NUMBER	SAMPLING TIME (24 HOUR)	TOTAL DEPTH (FT)	SAMPLING DEPTH (FT)	TEMP (CELSIUS)	SALINITY (o/oo)	CONDUCTIVITY (UMHOS/CM)
	DAY: OCTOBER 9, 1986					
H1	1030	5.5	0.0	20.7	15.0	22,000
			2.5	20.5	16.0	23,000
			5.5	21.0	16.0	23,200
H2	1055	11.0	0.0	20.0	19.0	26,000
			5.0	20.0	19.0	26,200
			10.0	20.0	19.5	26,300
H3	1110	5.5	0.0	20.5	19.0	26,500
			2.5	20.2	19.0	26,900
			5.5	20.2	17.5	24,200
H4	1130	7.5	0.0	19.8	20.0	28,000
			3.0	19.0	20.0	28,000
			7.0	19.0	19.9	27,900
H5	1140	13.5	0.0	20.0	19.9	28,000
			6.0	20.0	20.0	28,100
			12.0	20.0	20.9	28,200
H6	1150	11.5	0.0	20.0	21.5	28,000
			5.0	20.0	21.5	28,200
			10.0	20.0	21.5	28,200
H16	1200 (FIELD DATA SAME AS SAMPLE NO. H6)					
H20	1205 (FIELD BLANK)					

NOTE: HIGH TIDE MAXIMUM AT APPROXIMATELY 1200 HOURS

APPENDIX 6 (CONTINUED)

RAHWAY RIVER SAMPLING PROGRAM
SUMMARY OF FIELD DATA ON TOTAL AND SAMPLING DEPTH,
TEMPERATURE, SALINITY, AND SPECIFIC CONDUCTIVITY
IN SURFACE WATER
NEAR THE CARTERET IMPOUNDS
COLLECTED BY HYDROSYSTEMS, INC.
OCTOBER 9, 1986

HYDROSYSTEMS' SAMPLE ID NUMBER	SAMPLING TIME (24 HOUR)	TOTAL DEPTH (FT)	SAMPLING DEPTH (FT)	TEMP (CELSIUS)	SALINITY (o/oo)	CONDUCTIVITY (UMHOS/CM)
	DAY: OCTOBER 9, 1986					
L1	1655	6.0	3.0	20.5	17.0	24,500
L2	1645	8.5	4.0	20.0	17.9	25,000
L3	1615	3.5	2.0	19.9	18.5	26,000
L4	1730	5.0	2.0	20.0	19.5	27,500
L5	1720	9.0	5.0	20.0	19.5	27,500
L15	1725 (FIELD DATA SAME AS SAMPLE NO. L5)					
L6	1715	4.0	2.0	19.9	19.5	27,500
L7	1705	3.5	1.5	20.0	18.0	25,200
L8	1605	3.5	2.0	19.0	18.9	26,000
L20	1755 (FIELD BLANK)					

NOTE: LOW TIDE MINIMUM AT APPROXIMATELY 1844 HOURS